

CLAIMS

What is claimed is:

- 1     1.     A position sense interface for a micro-mechanical element,  
2     comprising:  
3             at least a first and a second electrically decoupled sense capacitors;  
4     and  
5     112     position detection circuitry comprising a differential charge integrator  
6     with input-sensed, output driven feedback.
- 1     2.     The position sense interface of claim 1 wherein said integrator  
2     includes an operational amplifier having an input and an output, and an  
3     input sensing, output driving feedback circuit.
- 1     3.     The position sense interface of claim 1 wherein said position  
2     detection circuitry operates over a first non-overlapping time period and a  
3     second non-overlapping time period.
- 1     4.     The position sense interface of claim 2 wherein the feedback is  
2     common mode.
- 1     5.     The position sense interface of claim 2 wherein the differential  
2     charge integrator senses common mode.
- 1     6.     The position sense interface of claim 2 wherein the feedback is time  
2     multiplexed.
- 1     7.     The position sense interface of claim 2 wherein the feedback is  
2     frequency multiplexed.
- 1     8.     The position sense interface of claim 2 wherein the feedback is

2 continuous-time.

1 9. The position sense interface of claim 1 wherein each said sense  
2 capacitor comprises at least one proof mass.

1 10. The position sense interface of claim 1 wherein the micromechanical  
2 element comprises:

3 a substrate and at least one proof-mass; and

4 wherein said first and second electrically decoupled sense capacitors  
5 comprise four independent terminals, each electrically decoupled sense  
6 capacitor comprising an independent terminal on said proof mass, and an  
7 independent terminal on said substrate.

1 11. The position sense interface of claim 1 further including a  
2 compensating charge on each said sense capacitor.

1 12. The position sense interface of claim 1 wherein each said sense  
2 capacitor includes at least two independent terminals such that said first  
3 and second sense capacitors have four independent terminals.

1 13. The position sense interface of claim 1 further including a first and  
2 a second reference capacitor.

1 14. The position sense interface of claim 13 wherein said first and said  
2 second reference capacitor are substantially equal.

1 15. The position sense interface of claim 13 further including at least one  
2 binary weighted capacitor array in parallel with at least one reference  
3 capacitor.

1 16. The position sense interface of claim 13 wherein a charge is applied  
2 to said position detection circuitry by a changing voltage applied to said  
3 reference capacitors.

1 17. An integrated circuit formed on a semiconductor substrate,  
2 comprising:  
3 a micromechanical structure formed in or on said substrate; and  
4 a position detection circuit formed in and on said substrate, and  
5 including an operational amplifier and a negative feedback circuit.

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1 18. The integrated circuit of claim 17 wherein said negative feedback  
2 circuit is an input-sensing, output driving feedback circuit.

1 19. The integrated circuit of claim 17 wherein said micromechanical  
2 structure includes a first proof mass and a second proof mass.

1 20. The integrated circuit of claim 19 wherein said first proof mass  
2 comprises a first sense capacitor and said second proof mass comprises  
3 a second sense capacitor.

1 21. The integrated circuit of claim 20 wherein said first and second sense  
2 capacitors are coupled in said feedback circuit.

1 22. The micromechanical system of claim 20 wherein said first proof  
2 mass and said second proof mass are connected so as to electrically  
3 decouple said sense capacitors.

1 23. The integrated circuit of claim 17 wherein said micromechanical  
2 structure includes:  
3 a substrate;

4 at least one proof-mass; and  
5 first and second electrically decoupled sense capacitors; and  
6 wherein said first and second electrically decoupled sense capacitors  
7 comprise four independent terminals, each electrically decoupled sense  
8 capacitor comprising an independent terminal on said proof mass, and an  
9 independent terminal on said substrate.

1 24. The micromechanical system of claim 17 wherein said operational  
2 amplifier includes at least a first input, and a first signal applied to said  
3 feedback circuit places said operational amplifier in unity gain feedback  
4 during a first non-overlapping time period.

1 25. The micromechanical system of claim 17 wherein a second signal to  
2 said feedback circuit places said operational amplifier in a charge  
3 integration mode during a second non-overlapping time period.

1 26. A position sense interface, comprising:  
2 an input-sensed, output-driven common mode feedback loop; and  
3 a differential operational amplifier having an input.

1 27. The position sense interface of claim 26 further including a negative  
2 feedback loop responsive to a differential input at the input of said  
3 differential operational amplifier.

1 28. The position sense interface of claim 26 further including sense  
2 capacitors in said feedback loop.

1 29. The position sense interface of claim 28 wherein said sense  
2 capacitors are formed by at least one proof mass.

1 30. The position sense interface of claim 28 further including reference  
2 capacitors.

1 31. The position sense interface of claim 28 further including feedback  
2 coupling capacitors.

1 32. The position sense interface of claim 28 further including feedforward  
2 capacitors.

1 33. The position sense interface of claim 28 further including unity gain  
2 feedback switches.

1 34. The position sense interface of claim 33 wherein said operational  
2 amplifier includes at least a first input, and a first signal applied to said unity  
3 gain feedback switches places said operational amplifier in unity gain  
4 feedback during a first non-overlapping time period.

R.126 1 35. The position sense interface of claim 34 further including output  
2 zeroing switches, wherein a second signal to said output zeroing switches  
3 places said operational amplifier in charge integration mode during a  
4 second non-overlapping time period.

1 36. The position sense interface of claim 28 further including output  
2 zeroing switches.

1 37. The position sense interface of claim 26 wherein said feedback loop  
2 operates over two recurring, non-overlapping time periods.

1 38. The position sense interface of claim 28 wherein said feedback loop  
2 operates over two recurring, non-overlapping time periods and during said

3 second time period, substantially equal charge is applied to sense  
4 capacitors.

1 39. A micromechanical structure including a position sensing interface  
2 coupled to the micromechanical structure, comprising:  
3 a substrate;  
4 at least one proof mass connected to said substrate;  
5 first and second sense capacitors formed by terminals located on  
6 said at least one proof mass and said substrate;  
7 an operational amplifier; and  
8 an input sensed, output driven, common mode feedback loop having  
9 an output,  
10 wherein said common mode feedback loop is coupled to said  
11 operational amplifier and said first and second sense capacitors.

1 40. The microelectromechanical structure of claim 39 wherein said  
2 output is representative of acceleration applied to the micromechanical  
3 structure.

1 41. The microelectromechanical structure of claim 39 wherein said  
2 microelectromechanical structure comprises an accelerometer.

1 42. A microelectromechanical structure comprising:  
2 a substrate;  
3 a suspension;  
4 at least one proof mass connected to said substrate by said  
5 suspension;  
6 a first terminal attached to said proof mass;  
7 a second terminal attached to said proof mass, and  
8 electrically isolated from said first terminal;

9 a third terminal attached to said substrate; and  
10 a fourth terminal attached to said substrate;  
11 wherein said first terminal and said third terminal form  
12 electrodes of a first capacitor, and said second and said fourth terminals  
13 form electrodes of a second capacitor.

1 43. The microelectromechanical structure of claim 42 wherein said first  
2 and second terminals are mechanically attached to said proof-mass, and  
3 electrically isolated from each other by at least one dielectrically-lined  
4 isolation trench.

1 44. The microelectromechanical structure of claim 42 wherein said  
2 suspension comprises an electrical connection to said first terminal.

1 45. The microelectromechanical structure of claim 42 wherein said  
2 suspension further comprises:

3 a first conductive beam; and

4 a second conductive beam;

5 wherein said first conductive beam is electrically connected to said  
6 first terminal and second conductive beam is electrically connected to said  
7 second terminal.

1 46. The microelectromechanical structure of claim 42 wherein said proof-  
2 mass is formed of silicon.